

AD-A203 966

NOT FILE COPY

NC FILE COPY

AFWAL-TR-38-1083

A METHODOLOGY FOR SCREENING POTENTIAL ARTIFICIAL
INTELLIGENCE APPLICATIONS



AE
Lt Eric N. Hanson
Artificial Intelligence Applications Office

JULY 1988

See p 1
PROCEEDINGS

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

DTIC
ELECTE
NOV 28 1988
S E D

AVIONICS LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433-6543

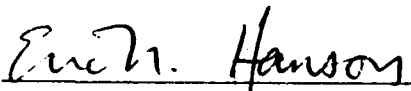
88 11 28 042

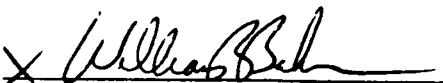
NOTICE

WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY GOVERNMENT-RELATED PROCUREMENT, THE UNITED STATES GOVERNMENT INCURS NO RESPONSIBILITY OR ANY OBLIGATION WHATSOEVER. THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA, IS NOT TO BE REGARDED BY IMPLICATION, OR OTHERWISE IN ANY MANNER CONSTRUED, AS LICENSING THE HOLDER, OR ANY OTHER PERSON OR CORPORATION; OR AS CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.


THIS REPORT HAS BEEN REVIEWED BY THE OFFICE OF PUBLIC AFFAIRS (ASD/CPA) AND IS RELEASABLE TO THE NATIONAL TECHNICAL INFORMATION SERVICE (NTIS). AT NTIS, IT WILL BE AVAILABLE TO THE GENERAL PUBLIC, INCLUDING FOREIGN NATIONS.

THIS TECHNICAL REPORT HAS BEEN REVIEWED AND IS APPROVED FOR PUBLICATION.


ERIC N. HANSON, 1LT, USAF
Technical Director

X 
WILLIAM R. BAKER
Chief, Artificial Intelligence
Applications Office

FOR THE COMMANDER

X 
PATRICK L. SISSON, Lt Col. USAF
Deputy Director
System Avionics Division
Avionics Laboratory

If your address has changed, if you wish to be removed from our mailing list, or if the addressee is no longer employed by your organization please notify AFWAL/AAAA, WPAFB, OH 45433-6548 to help us maintain a current mailing list.

Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

| REPORT DOCUMENTATION PAGE | | | | Form Approved OMB No. 0704-0188 | |
|---|-------|--|---|---|---|
| 1a. REPORT SECURITY CLASSIFICATION Unclassified | | | 1b. RESTRICTIVE MARKINGS None | | |
| 2a. SECURITY CLASSIFICATION AUTHORITY | | | 3. DISTRIBUTION / AVAILABILITY OF REPORT <i>Approved for public release; distribution unlimited.</i> | | |
| 2b. DECLASSIFICATION / DOWNGRADING SCHEDULE | | | 5. MONITORING ORGANIZATION REPORT NUMBER(S) | | |
| 4. PERFORMING ORGANIZATION REPORT NUMBER(S) AFWAI-TR-88-1083 | | | | | |
| 6a. NAME OF PERFORMING ORGANIZATION AFWAL | | 6b. OFFICE SYMBOL (If applicable) AAAA | 7a. NAME OF MONITORING ORGANIZATION Same as 6a. | | |
| 6c. ADDRESS (City, State, and ZIP Code) WPAFB OH 45433-6543 | | | 7b. ADDRESS (City, State, and ZIP Code) Same as 6a. | | |
| 8a. NAME OF FUNDING / SPONSORING ORGANIZATION See 6a. | | 8b. OFFICE SYMBOL (If applicable) See 6b. | 9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER _____ | | |
| 8c. ADDRESS (City, State, and ZIP Code) See 6c | | | 10. SOURCE OF FUNDING NUMBERS | | |
| | | | PROGRAM ELEMENT NO. 62204F | PROJECT NO. 2003 | TASK NO. 05 |
| | | | WORK UNIT ACCESSION NO. 54 | | |
| 11. TITLE (Include Security Classification) A Methodoloby for Screening Potential Artificial Intelligence Applications (Unclassified) | | | | | |
| 12. PERSONAL AUTHOR(S) Eric N. Hanson, Stephen E. Cross, and Allen Smith | | | | | |
| 13a. TYPE OF REPORT Proceedings | | 13b. TIME COVERED FROM _____ TO _____ | | 14. DATE OF REPORT (Year, Month, Day) July 1988 | |
| 15. PAGE COUNT 20 | | | | | |
| 16. SUPPLEMENTARY NOTATION | | | | | |
| 17. COSATI CODES | | | 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) | | |
| FIELD | GROUP | SUB-GROUP | 12.09 | | |
| _____ | _____ | _____ | | | |
| _____ | _____ | _____ | | | |
| 19. ABSTRACT (Continue on reverse if necessary and identify by block number, / This paper presents a method to rapidly evaluate a large number of possible opportunities to apply artificial intelligence technology. The domain expert for a povential application is interviewed briefly (for 1-3 hours) by a knowledge-engineering team. During this interview, the expert is questioned on a carefully chosen set of topics to help quickly assess the level of AI risk, systems engineering risk, and potential payoff of building the application(s) identified during the session. After conducting a series of these interviews for an organization, a report is written summarizing the results, and prioritizing the potential applications for future assessment and prototyping. () | | | | | |
| 20. DISTRIBUTION / AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS | | | 21. ABSTRACT SECURITY CLASSIFICATION Unclassified | | |
| 22a. NAME OF RESPONSIBLE INDIVIDUAL Eric N. Hanson | | | 22b. TELEPHONE (Include Area Code) (513)255-1491 | | 22c. OFFICE SYMBOL AFWAL/AAAA |

A Methodology for Screening Potential Artificial Intelligence Applications

Eric N. Hanson
Stephen E. Cross

*Air Force Wright Aeronautical Laboratories
Wright-Patterson AFB, OH 45433*

Allen Smith

Teknowledge Federal Systems, Inc.

Abstract

This paper presents a method to rapidly evaluate a large number of possible opportunities to apply artificial intelligence technology. The domain expert for a potential application is interviewed briefly (for 1-3 hours) by a knowledge-engineering team. During the interview, the expert is questioned on a carefully chosen set of topics to help quickly assess the level of AI risk, systems engineering risk, and potential payoff of building the application(s) identified during the session. After conducting a series of these interviews for an organization, a report is written summarizing the results, and prioritizing the potential applications for future assessment and prototyping.

1. Introduction

A wide variety of artificial intelligence (AI) applications have been built successfully using a knowledge-based expert systems approach. There are examples in industry [Fox84], finance [Cohe83], medicine [McDo84], military [Ande87] and other fields. However, many organizations have barely begun to explore the potential of expert systems. This represents a serious lag between technology and applications. Studies have shown that it normally takes 10-15 years for a new technology to be widely applied unless special measures are taken to accelerate transition of the technology to the field [Fird88].

To reduce this lag time in applying knowledge-base systems technology, it is important to systematically identify potential applications, and carefully decide which ones to pursue in order to maximize return on investment. In a large organization, there may be literally dozens of opportunities for building knowledge-based systems. A method is needed to do the following:

Appeared in Proc. WESTEX-88 Conf.
on Expert Systems, Anaheim, CA.,
June 1988.



| | |
|--------------------|-------------------------------------|
| Accession For | |
| NTIS GRA&I | <input checked="" type="checkbox"/> |
| DTIC TAB | <input type="checkbox"/> |
| Unannounced | <input type="checkbox"/> |
| Justification | |
| By _____ | |
| Distribution/ | |
| Availability Codes | |
| Dist | Avail and/or Special |
| A-1 | |



- identify as many of these applications as possible to help make sure the most promising ones are uncovered,
- quickly evaluate each application in terms of risk and value,
- prioritize the applications for future in-depth assessment and possible prototyping based on the results of the risk/value analysis,
- summarize the results of the process for management to help them make effective decisions about which applications to pursue.

This type of approach contrasts sharply with the more conventional method of developing AI systems. Normally, potential AI applications are considered one at a time, within individual operational organizations. This grass-roots approach makes it difficult for a large organization to maximize the organization-wide payoff for a given level of investment in AI technology. The goal of the approach described in this paper is to allow large organizations to make the most effective possible AI investment decisions.

The application screening methodology discussed here was developed by Teknowledge Federal Systems and the Dayton Center for Artificial Intelligence Applications (CAIA). The primary goal of the CAIA is to help the Air Force exploit AI technology. The Air Force, like any large organization, has many potentially high-payoff applications for practical artificial intelligence technology; the methodology described here was developed to provide an efficient technique for identifying those applications. A more detailed discussion of the CAIA is given below.

The Center for Artificial Intelligence Applications

The CAIA is an independent organization sponsored by the Air Force Wright Aeronautical Laboratories (AFWAL) and managed by the Miami Valley Research Institute (MVRI), a consortium of universities in the Dayton area. Technical coordination of Center activities is provided by Teknowledge Federal Systems, under a subcontract to MVRI. The Center has a threefold mission:

- to monitor and stimulate advances in the AI R&D community and transition emerging AI technologies into Air Force applications,
- to identify, assess, and prototype high-payoff applications for AI technology for the Air Force, and
- to provide education and training to expand the pool of professionals with AI skills in the Dayton area. The Center focuses on applying existing technology, stimulating and transitioning relevant new technology, training AI applications engineers, and improving the awareness of management about the capabilities of AI technology. The Center is strongly applications-oriented. Applied research and development sponsored by the Center is driven by identified Air Force applications requirements.

A key aspect of the Center's charter is the systematic identification and assessment of potential applications for AI technology in the Air Force. to meet this need for a systematic and replicable screening methodology, Teknowledge Federal Systems, working with the Air Force and MVRI, developed the methods outlined in this paper. Using



| | |
|---------------|-------------------------------------|
| tion For | |
| GRA&I | <input checked="" type="checkbox"/> |
| AB | <input type="checkbox"/> |
| anced | <input type="checkbox"/> |
| location | |
| button/ | |
| ability Codes | |
| Dist | Avail and/or |
| A-1 | Special |

these methods, the Center identifies the application opportunities available to the Air Force customer, analyzes those opportunities in terms of technical risk and potential payoff to the Air Force, and recommends a plan for pursuing the most promising applications further. The Center focuses primarily on relatively high-payoff applications. In terms of technical risk, however, the scope is broader and more eclectic; near-term applications of low-to moderate risk are encouraged, but high-risk work is not avoided if the payoffs are high and risk can be decreased by applying the results of relevant applied research.

The rest of this paper describes the method for performing the steps in the screening process. Section 2 describes the methodology in detail. Section 3 presents a case study where the application was applied to a particular organization. Finally, Section 4 summarizes and presents conclusions.

2. The Application Screening Methodology

A detailed breakdown of the steps in the application screening methodology is illustrated in Figure 1. Each of these steps is described in more detail below.

2.1. Prescreening

Distribute Initial Selection Questionnaire: To help gather information about potential AI applications in an organization, a questionnaire is distributed to key individuals. We have found it most effective to have the management of the organization give the questionnaire to people they feel are best qualified to complete it. The questionnaire we use is shown in Appendix A. We feel that the questionnaire is a good compromise between thoroughness and length. It captures the essence of a potential application, but it is not so long that people refuse to complete it.

Initial selection of problems to screen: The questionnaires and other information available about potential applications in the organization being screened are reviewed. Obviously inappropriate applications are culled out at this point. Screening sessions are scheduled for the remaining applications.

Pre-brief of Participating Experts and Managers: The pre-brief is a short meeting where members of the screening team explain the screening process to the organization being screened. At the pre-brief, the following points are made:

- It is very important that the person most familiar with the problem being presented (the expert) is the one who will be interviewed at the screening. There is a significant tendency of organizations to either send the expert's boss since the boss is more comfortable with public speaking, or send an apprentice since the expert is too busy to participate. Working with a manager who does not know the details or an eager but inexperienced person will not work.
- The people to be screened are asked to prepare a set of view-graphs using *templates* provided by the screening team. The templates are designed to be easy for the expert to complete, and still communicate the most essential information to the screening team. It is important to give the person(s) being screened a format to follow since otherwise they tend to bring in slides or other materials they have prepared for other presentations, or prepare a presentation that gives a general overview of what they do. These materials usually are not very effective at communicating the nature of the problem and the problem-solving strategies used by

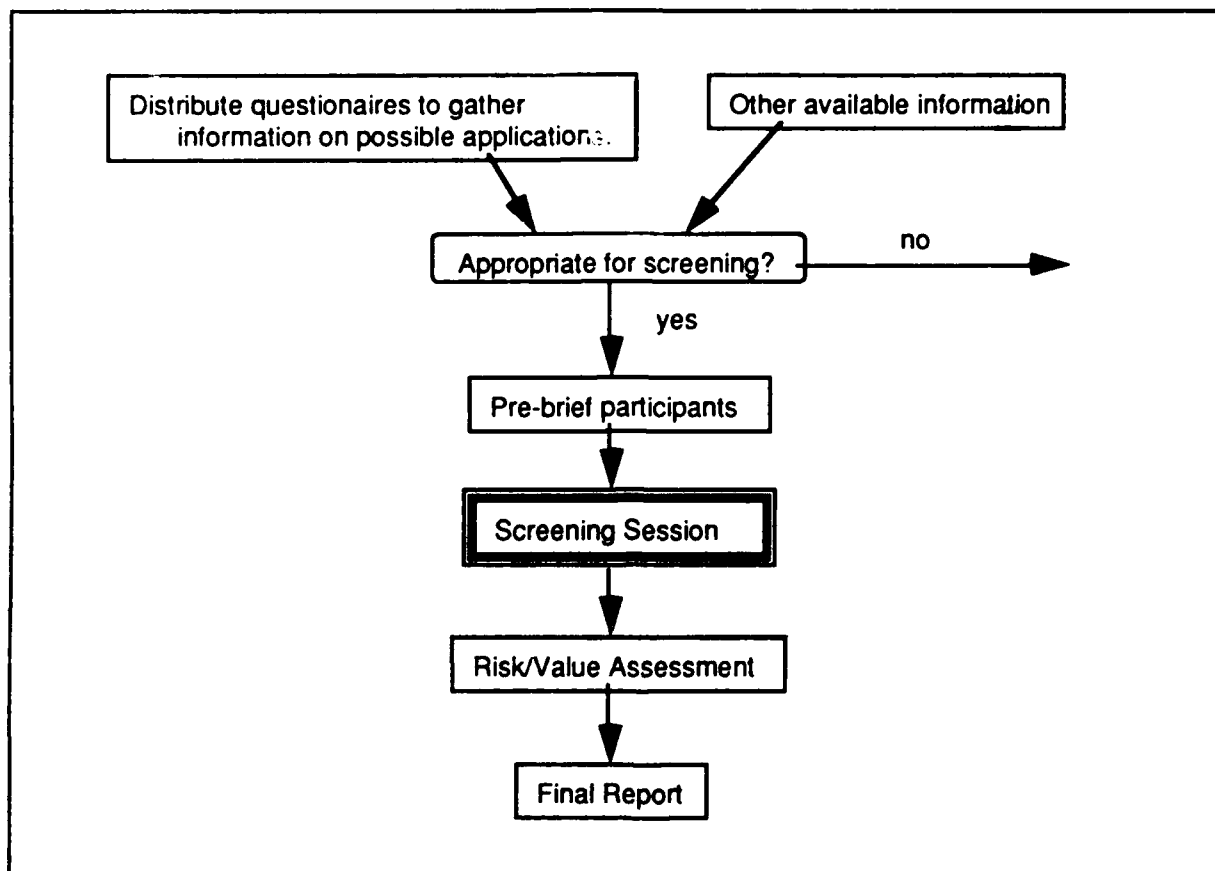


Figure 1. The Application Screening Process:

the expert. An outline of the templates used is shown in Appendix B.

2.2. Screening Interviews and Analysis

The Screening Session: The screening session itself is a 1-1/2 to 3 hour informal interview with the expert. The session is conducted by the *screening team* which will be discussed in more detail in the next section. The essential people at the screening session are the expert, and the screening team leader. Other people may be present at the session, including additional screening team members, and interested people associated with the expert, possibly including co-workers and management.

At the beginning of the session, the team leader introduces the team to the expert, and describes the format of the session. The expert is reassured that the session will be a friendly interview (not an inquisition) and the format will be loosely structured. The template slides completed by the expert will serve as a guide, and there will be frequent questions by the team leader and perhaps other team members.

During the session, the expert gives a presentation on his or her area of expertise based on the template slides. The team leader will interrupt as necessary to ask questions to gather information that will help determine the AI application opportunity (or opportunities) related to the experts discussion, and, for each application opportunity identified, the AI risk, the systems engineering risk, and the value of the application if successful. The questions asked are guided in part by the items on the screening form described below.

Analysis: the Application Screening Profile. Simply stated, the goal of an application screening is to evaluate each candidate application along two dimensions of technical risk and one dimension of value, as indicated below: The purpose of the screening form is to graphically represent the judgements of the screening team along each of the above dimensions of risk and payoff.

- **Systems Engineering Risk:** This dimension focuses on the application system as a whole, both intelligent and conventional modules. and evaluates the technical risks associated with prototyping and fielding that system. Dimensions of risk that are evaluated include:
 - System complexity (number of intelligent vs. conventional modules, integration requirements),
 - System scalability (ability to scale from prototype to full system without major redesign,
 - Performance requirements,
 - Hardware requirements for development and delivery,
 - Software requirements for development and delivery, and
 - Maintainability (extent to which knowledge and data in the system will require frequent modification and updating).
- **AI Technical Risk.** Focusing only on the AI components of the system, criteria on this dimension evaluate the extent to which these components challenge the current state of AI technology. Dimensions of AI technology risk evaluated include:

- Type of application,
- Nature and availability of expertise
- Complexity/difficulty of the task to be performed,
- Anticipated role of the system,
- Size/complexity of the knowledge base,
- Applicability of current AI tools,
- Advanced technology requirements.

If the application is at or beyond the current state of the art in artificial intelligence, or if a piece of advanced technology would significantly improve the system, there may be an opportunity for the Center to support a collateral Applied R&D Project targeted at the candidate application.

- **Value:** This dimension looks at the potential payoff from the system. Payoffs can be economic, (i.e. cost savings), and non-economic (enhanced survivability or mission effectiveness). Another dimension of payoff is in the generality of the system; with relatively minor changes, the system developed for the candidate application may be adaptable to some other problems in the Air Force. Value is of course tempered by cost; although precise estimates are difficult to obtain during screenings, rough approximations can be developed for the cost of developing both the prototype and fielded system.

The purpose of the Application Screening Profile is to graphically represent the judgements of the screening team along each of the above dimensions of risk and payoff. An actual copy of the screening form, completed for the Fuel Specimen Analysis application (to be discussed later), is shown in Appendix C. One side of the form has slots to be filled as well as labeled scales to mark, and on the other side has instructions for marking the scales. There is a major scale for each of the three broad categories already identified (AI risk, systems engineering risk, and value). Under each of these major categories, there are several more specific scales. The specific scales are used to gather detailed information that makes it fairly straightforward to make overall risk and value assessments for the major categories. A mark is made on each major scale that essentially summarizes the specific items under it.

Judgement is required to summarize the marks on the detailed scales to come up with an assessments for the major categories. It is not wise to apply a simple formula such as taking the maximum of the detailed scale values to come up with the value for the major scale. If one of the detailed items indicates high risk, and the screening team feels that that item is a "show stopper" (i.e. its effect dominates the effects of the other items) then it is appropriate to mark the major scale at the same point. However, if the high risk indication for a particular item does not dominate the others, it is appropriate to average the detailed scale marks to generate the mark on the major scale.

2.3. Report Preparation

The Screening Report: This report summarizes the results of the assessment. Normally, many potential applications within a large organization are screened. A complete report is created that discusses all the application areas screened within the organization. The report has the following format:

- Introduction
- Description of Application Screening Procedures and Criteria
- One section for each *Application Area*

Each application area section contains a logical grouping of one or more potential applications. There is one subsection for each potential application. The format of these subsections is as follows:

- Opportunity: (title of the potential application)
 - Description
 - Recommendation
 - Discussion
- Overall Conclusions and Recommendations
- Appendices
 - Screening Profiles (from the screening forms)
 - Suggested Advanced Technology R&D Areas
 - Application Screening Summary

A few sections of this report merit more discussion. For a particular application opportunity, the *Description* section normally contains a paragraph that concisely describes the proposed application. The *Recommendation* section contains one of the following possible recommendations (or a customized recommendation if the ones below are not appropriate):

1. Pursue
2. Pursue with constraints
3. Pursue (guarded)
4. Applied R&D Only
5. Re-examine Later
6. Do Not Pursue

pursue (1) is used for those applications that clearly have high value and relatively low risk. *pursue with constraints* (2) is used for applications that have high potential value, but will not be successful unless some conditions are met (for example, a database must be built first, or the one available expert must agree to postpone retirement for six months while the system is built). *pursue (guarded)* (3) is for applications that seem promising, but have a higher ratio of risk to value than for (1) and (2). *Applied R&D Only* (4) is for high value applications which would be difficult or impossible to build with current technology. This recommendation indicates a problem area where applied research is needed. *Re-examine Later* (5) indicates an application that would not be wise to pursue now (for example, due to lack of operational expertise) but which may be worthwhile to pursue in the future (e.g. once enough expertise has been gathered). *Do Not Pursue* (6) is for applications that have a high risk-to-value ratio.

Making the cut: Invariably, after screening a large organization, building all the potential applications with "pursue" recommendations would require more money and manpower than can be spared. Hence, some subset of the applications must be selected for development. Clearly, the goal should be to maximize the expected return on

investment. The problem is complicated by the fact that there are many possible types of "return," including

- financial payoff,
- increased performance (e.g. improved sortie rate),
- increased acceptance by top management etc.

Deciding which applications to pursue is complicated by the fact that the those with the highest potential payoff also have the highest risk, or require the most development effort. We address these concerns using the following strategy:

1. Select one or more low-risk applications for early development to foster support from management in the organization as early as possible. These should be the highest-payoff low risk applications available.
2. Select applications from those that remain to give maximum expected return on investment. This may involve applications that are high risk, or will be expensive to develop.

The first step toward building an application is to do an in-depth assessment to find whether the application is feasible, and determine how much manpower, time, hardware and software resources will be required. The application will be prototyped only if it still is favorable in terms of risk and potential payoff after the assessment. A full discussion of the methods used to do the assessment and prototype are beyond the scope of this paper. In the next section, we give a case study of applying the screening methodology in a large organization.

3. Applying the Methodology: A Case Study

This section presents an actual case study of applying the screening methodology to two US Air Force organizations, the Propulsion Laboratory, which is a part of the Air Force Wright Aeronautical Laboratories (AFWAL), and a Program Office in Aeronautical Systems Division (ASD/SC). Both are located at Wright-Patterson AFB, Ohio. A brief overview of the application areas presented will be given, followed by a more detailed discussion of an individual application opportunity, Fuel Specimen Analysis. To begin the screening process, representatives from the Propulsion Laboratory were briefed one week in advance to help them prepare for the sessions. The session format was explained to them, and they were given templates of slides which they were asked to have the domain experts prepare prior to the sessions. The sessions themselves required three work days (January 12-14, 1988). A summary of the results of the ASD/SD and Propulsion Lab report appears in the table in Appendix D. The table is designed to quickly identify the applications opportunities, identify the AI risk, systems engineering risk, and value using graphical icons, show the recommendation for each application, and list areas where advanced research and development may be needed. The portion of the final report for the Fuels Analysis problem area is shown in Appendix E.

4. Conclusions

The beauty of the application screening methodology presented in this paper is that it allows a large number of possible AI applications to be identified and prioritized in a short time. The screening process provides a good preliminary picture of the risk and value of each potential application through an interview process guided by the use of an

application screening profile. The profile contains a carefully selected set of questions designed to help derive good estimates of the AI risk, systems engineering risk, and potential value of each application opportunity. The results of screening many problems in a large organization are summarized in a report. A key feature of this report is a single-page chart summarizing the results. The contents of the report provide highly valuable guidance to the management of the organization screened, helping them focus their AI resources on the best applications.

The screening methodology presented in this paper is not a substitute for *in-depth assessment*. It is designed to give a good "first cut" at a large number of possible applications. Only the most promising applications identified during the screenings will be pursued further through in-depth assessment and prototyping.

The methodology presented here has been successfully applied on a large scale in the Aeronautical Systems Division (ASD) of Air Force Systems Command. Over 200 opportunities for applying knowledge-based systems technology have been identified, including at least one likely to provide multi-million dollar pay-off on the funds used for development. The experience at ASD indicates that the AI application screening process is a highly effective tool. Strategic planners in other organizations would be well-advised to adopt the methodology for their organizations to keep their competitive edge.

References

- [Ande87]
Anderson, D. and C. Ortiz, "AALPS: A Knowledge Based System for Aircraft Loading," *IEEE Expert*, Winter 1987, pp. 71-79.
- [Cohe83]
Cohen, P., and M. D. Lieberman, "A Report On Folio: An Expert Assistant for Portfolio Managers," *Proceedings of IJCAI*, 1983, pp. 212-14.
- [Fird88]
Firdman, H. E. Expert Systems: Are You Already Behind? *ComputerWorld*, April 18, 1988.
- [Fox84]
Fox, Mark S. et al., "ISIS: A Knowledge-Based System for Factory Scheduling," *Expert Systems*, Vol. 1, No. 1, 1984.
- [McDo84]
McDonald, Clement J., et al., "CARE: A Real World Medical Knowledge Base," *Proceedings of CompCon, Spring 1984*, pp. 187-91.

Appendix A: Problem description questionnaire

1. What is the application?
 - a. Describe the application in a nutshell. What benefit does it offer or what problem

does it solve?

- b. What is the subject matter area (general and specific)?
- c. What exactly is the task to be performed? In a paragraph, what would the system do?
- d. Why is the application important? How does it impact the organization?
- e. What are the inputs to the application (e.g. sensors, test results, data in databases, questions from novices seeking advice, poorly formed queries of users seeking data, a proposal to be critiqued)?
- f. What are the outputs of the application (e.g. a diagnosis, a plan for performing a task, a precise database query (or collection of queries), an engineering design or diagram, a document)?
- g. How does this application fit into the larger picture of the organizations operation?
- h. If the system is successful, what will be the payoff for the organization?
- i. How soon is the application needed? Are there time constraints?
- j. What approaches have been tried in the past to solve the problem?

2. What issues must be faced by the organization to field a working system?

- a. does the system have to be integrated with existing hardware or software?
- b. Will a change in existing procedures or policy be required to use the system? How extensive a change?
- c. What will be the consequences if the system fails to perform?
- d. How receptive and/or adaptable to new technology are the people who will use the system?
- e. What kind of financial constraints exist?
- f. Any other constraints?

Appendix B

Outline of slide templates for application overview briefing to be given by application expert (one slide for each of items 1-7).

1. Application Characterization

- Application Overview
- Role of the Application

2. Application Situations

- examples of situations the application would be expected to handle.

3. Overall Flow

- Outline of the flow of the expert's decision-making process.

4. Expertise

- Types and sources of expertise that can be applied to the problem.

5. Example Case: Circumstances

- Circumstances surrounding the specific example case (problem-solving situation). Hints: What are the symptoms? What relevant past history, if any, is available regarding this case and its environment?

6. Example Case: Step-By-Step

- Detailed breakdown of steps in solution of example case. For each step, this includes
 - step description
 - input information desired
 - knowledge used in selecting action
 - action
 - result

7. Example Case: Variance

- The expert's analysis of how the case was handled when it actually occurred. Hints: If you handled the case, would you handle it the same way as today? If you didn't handle the case, would you address it differently?

157,000

FT-1: Fuel
Specimen
Analysis

| Application | Analysis | Report | Forward |
|-------------|----------|--------|---------|
| | | | |

Organization AFWMA/A25F

Answer

| System Engineering Maturity | | System Engineering Maturity | |
|-----------------------------|------|-----------------------------|------|
| Low | High | Low | High |
| 1. System Complexity | | | |
| PC life | | | |
| Integration | | | |
| 2. System Scalability | | | |
| 3. Performance Requirements | | | |
| 4. Hardware Requirements | | | |
| Development | | | |
| Delivery | | | |
| 5. Software Requirements | | | |
| Development | | | |
| Delivery | | | |
| 6. Maintainability | | | |
| Value & Cost | | | |
| 1. Economic Value | | | |
| 2. Effectiveness | | | |
| 3. Generality | | | |
| 4. Cost | | | |
| AI Components | | | |
| Conventional Components | | | |
| Applied R&D | | | |

Application Screening Profile for FT-1: Fuel Specimen Analysis.

Appendix C ctd. (reverse side of application screening profile)

AI RISKS

Scale 1 - Type of Application

Interpret: Transference of signals from the external environment to a symbolic representation.
For example, Signals -> Wave Form Phase Data, Optical Signals -> Intensity/Time Ratio.
Assess: Receive intermediate classifications as input and produce a higher-level classification (situation assessment) for use by Planning. For example, Wave Form Phase Data -> Nuclear Explosion; Test Results -> Implied Faults.
Plan: Receive a situation assessment as input and produce a plan as output. For example, Implied Faults -> Repair; Repair -> Tactics Plan.
Act: Execute a plan. This phase occurs only in autonomous systems.
Check: To select from among a fixed, enumerable set of alternatives.
Critique: To analyze and evaluate a composite entity relative to a fixed standard, using criteria for correctness, completeness, etc.
Construct: To assemble a composite entity from a fixed, enumerable set of constituent element types, subject to a fixed set of rules.
Create: To build a composite entity from a set of constituent element types, subject to rather general principles or rules.

Scale 2 - Nature and Availability of Expertise

Nature of Expertise: Low Risk Easy to express verbally.
High Risk Expressible verbally, but difficult.
Low Risk Partially expressible verbally, requires some performance.
High Risk Performance-based expression, verbalization extremely difficult and unreliable.
Availability: Low Risk Significant operational expertise exists.
High Risk Some operational expertise exists.
Low Risk No operational expertise; only analysis.
High Risk No operational or analysis expertise analytical/theoretical.
Low Risk Cases already exist and provide good coverage of all situations.
High Risk None exist; readily available.
Low Risk None exist; significant resources needed to create.
High Risk None exist; cases must be created.
Low Risk High Domain Coverage.
High Risk Low All experts cover entire domain.
Low Risk Experts specialize in areas of domain.
High Risk Experts specialize, and more can represent the entire domain.
Expert Agreement: Low Risk Little or no agreement.
High Risk Little or no agreement.
Low Risk Low Expertise is stable. Knowledge required in one year will be essentially the same as today's.
High Risk High variability. Expertise is evolving quickly.

Scale 3 - Complexity/Difficulty of Task

Low Risk Straightforward for any practitioner.
High Risk Straightforward for expert.
High Risk Moderately difficult for expert.
High Risk Very difficult for expert; often unworkable.

Scale 4 - Size and Complexity of Knowledge Base

Size: Low Risk Very small (less than 50).
High Risk Small (1-200).
High Risk Medium (200 to 700).
High Risk Large (700 to 1,000).
High Risk Very Large (>10,000+).

Prototypability:

Low Risk Meaningful prototype can be defined that is less than full system in depth and breadth.
High Risk Need full depth for prototype (complete functionality).
High Risk Need full breadth for prototype (complete scope).
Low Risk No meaningful prototype can be defined that is less than the full system.
Low Risk No redesign required, and only moderate knowledge base augmentation is increase scope and functionality.
High Risk No redesign, but substantial knowledge base augmentation required.
High Risk Redesign required to increase scope and functionality.

Scale 5 - Applicability of Current AI Tools

Low Risk Current commercial tools OK with no extensions.
High Risk Current research tools OK with no extensions.
High Risk Requires extension of current tools.
High Risk No current tools will work.

Scale 7 - Advanced Technology Requirements

Low Risk None. Application can be developed using well-understood technology.
High Risk Optimal. Application does not require advanced technology, but does provide opportunities.

SYSTEM ENGINEERING RISKS

Scale 1 - System Complexity

Low Risk Single intelligent module.
High Risk Single intelligent module + conventional modules.
High Risk Multiple intelligent modules.
High Risk Multiple intelligent modules + conventional modules.
Integration: Low Risk Low interaction among modules.
High Risk Moderate interaction among modules.
High Risk High interaction among modules.

Scale 2 - System Scalability

Low Risk No redesign required, and only moderate knowledge base augmentation to increase scope and functionality.
High Risk No redesign, but substantial KB augmentation required.
High Risk Redesign required to increase scope and functionality.

Scale 3 - Performance Requirements

Low Risk Minutes.
High Risk Seconds.
High Risk Milliseconds.

Scale 4 - Hardware Requirements - Development and Delivery

Low Risk New Specified.
High Risk Specified AI (e.g., Symbolic).
High Risk Non-specified non-AI (e.g., VAX).
High Risk Specified non-AI.
High Risk Special Hardware (e.g., minis processors).

Scale 5 - Software Requirements - Development and Delivery

Low Risk New Specified.
High Risk Specified AI (e.g., Lisp, REE).
High Risk Non-specified non-AI (e.g., C).
High Risk Specified non-AI (e.g., Ada).

Scale 6 - Maintainability

Low Risk None. Once built the system will require little maintenance.
High Risk Moderate.
High Risk High. System maintenance will approximate system development effort.

VALUE & COST

Scale 1 - Economics, e.g., Cost Savings

Low Value Less than or equal to life-cycle costs of the system.
High Value High Cost.

Scale 2 - Effectiveness, e.g., Survivability, Reliability, PkF

Low Value Low.
High Value Low.
High Value High.

Scale 3 - Generality

Low Value One time use for system.
High Value Adaptable to many high payload applications in organization.

Scale 4 - Cost (person-years for prototype and for full system)

Conventional Components
0 person-years for prototype, 0 person-years for full system.
1 person-year for prototype, 1 person-year for full system.
5 person-years for prototype, 5 person-years for full system.
10 person-years for prototype, 10 person-years for full system.
20 person-years for prototype, 20 person-years for full system.

AERO PROPULSION LABORATORY

| Application | AI RISK VALUE | | | Recommendation | | R & D |
|--|------------------|---------|-------|----------------|--|--|
| | AI RISK | SE RISK | VALUE | Recommendation | | |
| ASD/SC: Program Office | | | | | | |
| PO-1: SOW Advisor | ● | ● | ● | Pursue | | Intelligent System V & V |
| PO-2: RFP Advisor | - | ● | ● | Re-examine | | |
| PO-3: Contract Writing | - | ● | - | Re-examine | | |
| PO-4: Program Management | - | ● | - | Re-examine | | |
| AFWAL/POT: Turbine Engine | | | | | | |
| TE-1: Turbine Engine Cycle Analyzer | ● | ● | ● | Pursue | | Turbine engine model based reasoning; Temporal reasoning; |
| AFWAL/POPA: Advanced Propulsion | | | | | | |
| ADVP-1: System Optimization Through Parametric Studies | ● | ● | ● | Re-examine | | |
| AFWAL/POOC: Aerospace Power | | | | | | |
| AEROP-1: Autonomous Solar Array | ● | ● | ● | Pursue | | |
| AFWAL/POMC: Operations | | | | | | |
| OP-1: Network Management | ● | ● | ● | Re-examine | | |
| AFWAL/POSE: Fuels | | | | | | |
| FT-1: Fuel Specimen Analysis | ● | ● | ● | Pursue | | |
| FT-2: Molecular-Level Design | - | - | - | Re-examine | | Qualitative models of chemical Processes |

KEY: AI & SE Risk--- ○ = LOW ● = LOW Value--- ● = MODERATE ○ = MODERATE ● = M-H ○ = M-H ● = HIGH ○ = HIGH

Appendix E: Final Report for Fuels Specimen Analysis

Opportunity FT-1: Fuel Specimen Analysis

Description

This opportunity was described by Lt. Howard. Whenever an aircraft mishap occurs, whether military or commercial, specimens of the jet fuel involved in the mishap are usually collected and sent to the Fuels Branch for analysis. The objective of the specimen analysis is to detect and identify any connection between the fuel and the mishap. In addition to the fuel specimen, the analyst may receive a background report on the mishap, including the maintenance record and refueling history of the aircraft. Mishaps include crashes, fuel system shut-down on takeoff, flameout at altitude, premature combustor line burn-through, and any other event not having a readily apparent proximate cause, e.g., a ground fire. The Fuels Branch may be asked to perform as many as 60 analyses per year.

In performing the analysis, the first step is to select the tests to be performed. Tests are selected to verify some hypothesis or to resolve an ambiguity among hypotheses. Test sequencing is determined by the cost of performing the test, in terms of both its destructiveness and the time required for its performance. After completion of a battery of tests, results are interpreted and reported. If results are ambiguous, new tests may be conducted to resolve the ambiguity.

The planning of tests is a key task in the process, and it is heavily dependent on expertise. An expert analyst uses knowledge available from previous incidents, knowledge of the operating features of particular aircraft, engines, and fuel systems, and knowledge of effects of environmental conditions and contamination to select and sequence the most relevant tests. Unfortunately, expertise is limited and experts are often not available to plan an analysis. When experts are not available, inappropriate tests may be conducted, often those prescribed by the requestor, which lead to unnecessary testing and inconclusive results. The problem is exacerbated by a tendency to assume that fuels are the causes rather than hardware or other material, problems that may be more difficult to correct. This tendency generates many repetitive, unnecessary tests which require large amounts of expert time.

Lt. Howard proposed an expert system that would provide advice to an analyst on test selection and sequencing and on interpretation of results. The system would capture the expertise of existing experts and would serve as a surrogate for the expert in routine analyses, which represent the majority of cases. This would free the experts to concentrate on the difficult, high-priority problems while decreasing the average time to performance analyses.

Recommendation

Pursue (unqualified). The screening team feels that this application opportunity may be well suited to an intelligent systems approach and recommends that it be pursued further with a full-scale assessment.

Discussion

| | |
|--------------|---|
| AI Risk | <-----X-----> |
| SE Risk | <--X-----> |
| Value & Cost | <-----X-----> |
| | Low Moderate High |

Key knowledge, software and systems engineering factors for this application opportunity include:

- **AI Risk**

1. *Type of Application.* The application involves assess/choose (diagnosis of the situation), plan/choose (select tests), and plan/construct (sequence selected repairs).
2. *Nature and Availability of Expertise.* Expertise is expressible and available. Experts specialize, but there is a representative of the entire domain.
3. *Complexity/Difficulty of Task.* The task is straightforward for an expert.
4. *Role of the System.* The proposed system would advise a non-expert analyst.
5. *Size/Complexity of KnowledgeBase.* The knowledge base is expected to be of moderate size. Complexity is estimated as low to moderate.
6. *Applicability of Current AI Tools.* Current commercially available tools will be adequate for this application.
7. *Advanced Technology Requirements.* None.

- **Systems Engineering Risk**

1. *System Complexity.* The system will consist of a single intelligent module.
2. *System Scalability.* Low to moderate augmentation of the intelligent system is expected in moving from a prototype system to a full system.
3. *Performance Requirements.* No performance requirements are specified.
4. *Hardware Requirements.* No hardware is specified.
5. *Software Requirements.* No software is specified.
6. *Maintainability.* System maintenance should be low to moderate.

- **Value & Cost**

1. *Economic Value.* The economic value is expected to be moderate, attributable to costs savings attributable to using less-skilled analysts.

2. *Effectiveness.* The system should have a moderate impact on effectiveness, due faster, more relevant analyses.

3. *Generality.* Generality is moderate because the concepts and general approach should be transferable to other diagnosis/decision-support systems.

4. *Cost.* The cost of developing a prototype and full system is low: about one person-year.